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An In-situ AFM Investigation of Protein Crystallization. T.A. LAND, J.J DE YOREO and J.D. LEE, Lawrence Livermore National Laboratory, Livermore, CA 94550, A.J. MALKIN, YU.G. KUTZNETSOV and A. McPHERSON, University of California at Riverside, Riverside, CA 92521.
In situ atomic force microscopy (AFM) has been used to investigate the crystallization of the storage protein canavalin during both dislocation controlled step-flow and 2D nucleation controlled multilayer growth at low and high supersaturation, s, respectively. From the dependence of terrace width on s, the critical step length and critical island size we calculate a step edge free energy of 0.8eV. The occurrence of 2D nucleation on large (~10 mm) terraces and its absence on narrow (~1mm) terraces and the observation of step homogenization with an exponential time dependence for step-pair decay indicates that the supply of molecules to the steps is via surface diffusion with a barrier to down-step diffusion and a diffusion length of ~1mm. Step speeds are found to vary linearly with concentration and give a pH dependent kinetic coefficient for step motion of (0.6 to 3)x10^{-4} cm / sec. A quantitative analysis of the dependence of step speed on terrace width using the model of Gilmer, Ghez and Cabrera, leads to estimations for the activation energies for adsorption and incorporation of 0.1eV and 0.2eV respectively. Micro-crystal sedimentation and incorporation during growth leads to extreme distortion of the lattice through formation of many stacking faults and micro-grain boundaries. This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-ENG-48.